Lubrecht Fire-Fire Surrogate Study: Fuel treatment effects in ponderosa pine and dry mixed-conifer forests

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NORTHERN ROCKIES FIRE SCIENCE NETWORK

JOINT FIRE SCIENCE PROGRAM

Rocky Mountain Research Station

W.A. FRANKE COLLEGE OF FORESTRY & CONSERVATION
UNIVERSITY OF MONTANA

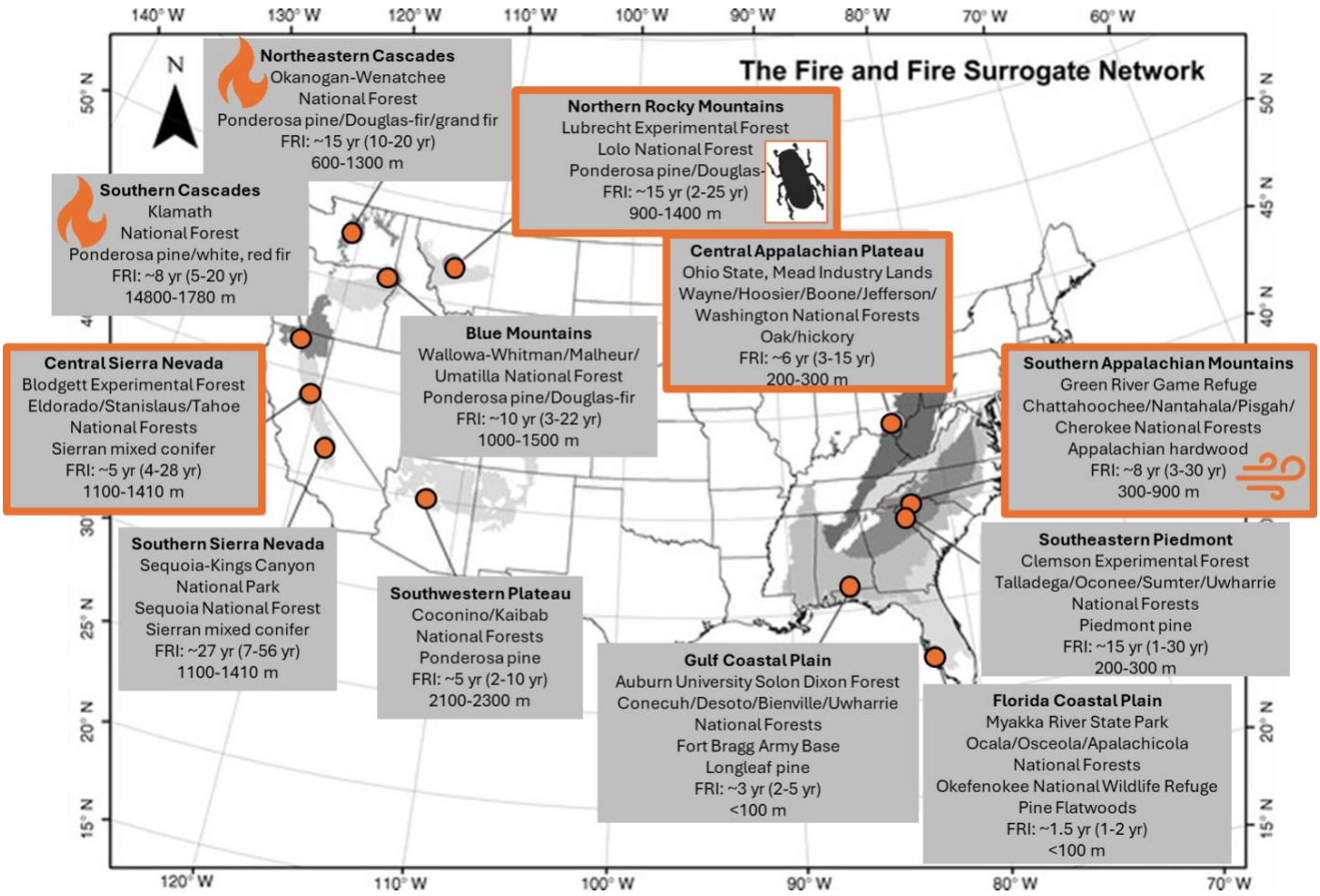

Figure 1. The National Fire and Fire Surrogate Study Sites. Sites outlined in orange are active.

Please note, some data presented in this handout is preliminary and subject to change

Background

The Northern Rockies Fire &Fire Surrogate study (Lubrecht FFS) was established in 2000 on the University of Montana's Lubrecht Experimental Forest as one of 12 sites in the National Fire & Fire Surrogate Study network (figure 1). The goal of the multidisciplinary project was to quantify the short-term (<4 years) effects of fuel reduction treatments in frequent-fire forests across the U.S. Only Lubrecht and three other sites in the FFS network remain active.

The original primary objective at Lubrecht FFS (and for all the National FFS study sites) was to implement treatments to reduce the likelihood of high-severity wildfire, such that 80% of the dominant and co-dominant trees would survive a wildfire burning under 80th percentile weather conditions. A second main objective at Lubrecht FFS was to restore the site to a forest structure and composition that more closely resembles historical reference conditions of ponderosa pine dominated, fire-maintained forests. The desired future conditions at the site are uneven-aged, relatively open, spatially complex structure that would increase resilience to wildfire, drought, and bark beetle outbreaks. The Lubrecht FFS site was established using a full-factorial, replicated block design with crossed thinning and prescribed burning treatments (figure 2). Each treatment is about 9-10 ha (22-25 acres).

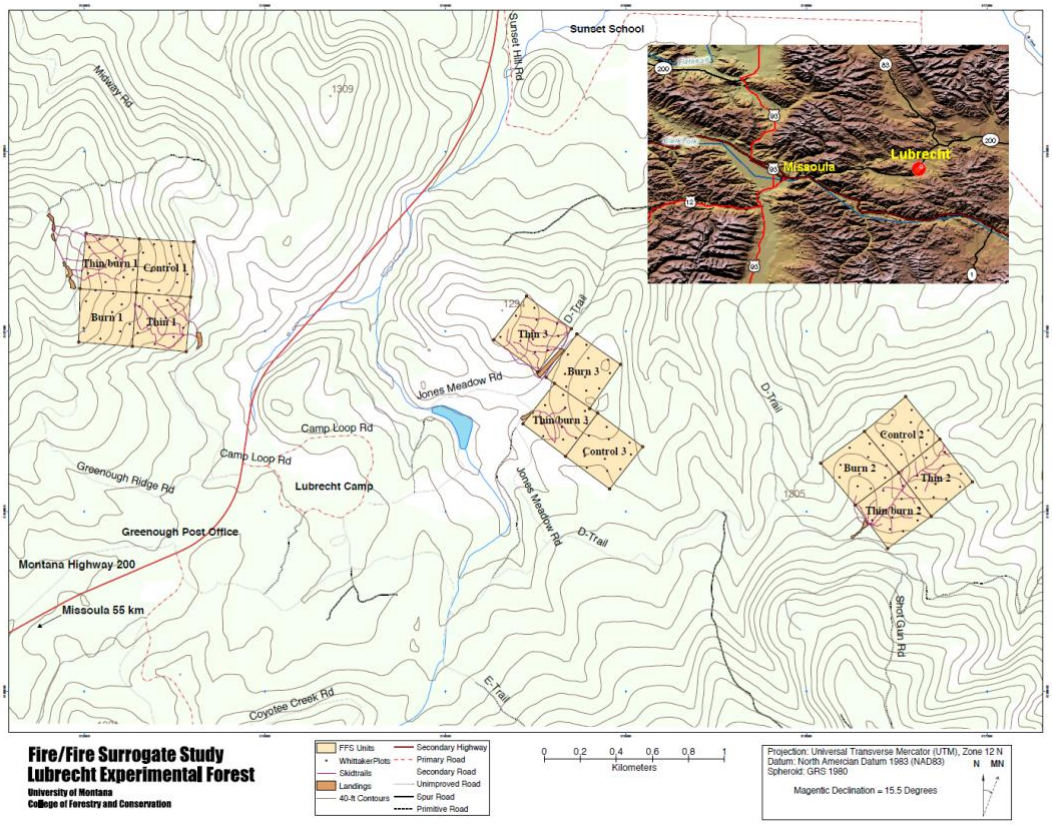

Figure 2. The Lubrecht Fire and Fire Surrogate Study layout.

Fire History

The historical fire frequency at Lubrecht Experimental Forest was 2-14 years, with the majority of fires occurring in the early growing season (figure 3).

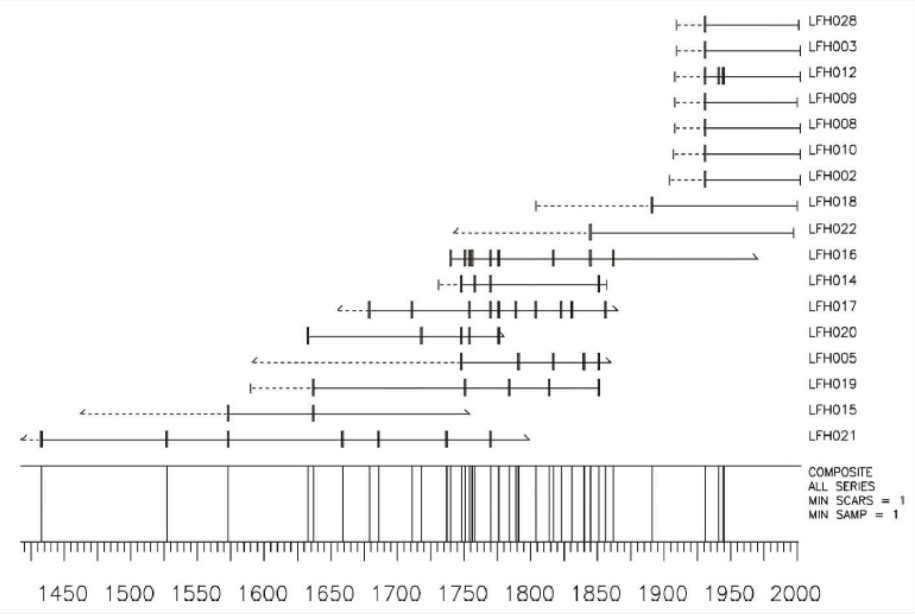

Figure 3. Fires at Lubrecht Experimental Forest. Each horizonal line is one tree and small vertical lines indicate the fire scar year. The long vertical lines at the bottom show the years where fires occurred on the experimental forest.

Silvicultural Cutting and Prescribed Burning Treatments

First Treatments: Thinning: 2001; Spring burning: 2002

Four treatments were evaluated for their effectiveness in moving stands toward desired future conditions (i.e., relatively open, large-tree dominated, primarily ponderosa pine/seral species composition, uneven-aged, randomly arranged, with scattered openings).

- The *control* treatment involved no thinning or burning.
- The *burn-only* (BO) treatment involved prescribed broadcast burning in the spring.
- The *thin-only* (TO) included low thinning and improvement/selection cutting.
- The *thin-burn* (TB) treatment included low thinning and improvement/selection cutting, followed by broadcast burning the following spring.

The thinning treatment units were marked:

- target basal area of 48-50 ft^2 $acre^{-1}$
- Leaving healthy, larger (≥15 in DBH) trees in the following order: ponderosa pine>western larch>lodgepole pine>Douglas-fir
- Leaving modest numbers of healthy, medium-sized and smaller ponderosa pines

Second Treatments: Thinning and mastication: late winter-early summer 2023; Spring burning: 2024

The same basic treatments were retained during a 2^{nd} entry with slight modifications.

- The *control* treatment involved no thinning or burning.
- The *burn-only* (BO) treatment involved prescribed broadcast burning in the spring with the intent to kill trees to reduce density.
- The *thin-only* (TO) included low thinning and improvement/selection cutting designed to increase spatial variability and openings followed by mastication of the majority of regeneration and slash.
- The *thin-burn* (TB) treatment included low thinning and improvement/selection cutting, followed by broadcast burning the following spring.

The thinning treatment units were marked:

- target basal area of 45 ft^2 $acre^{-1}$
- Leaving healthy, larger (≥15 in DBH) trees in the following order: ponderosa pine>western larch>lodgepole pine>Douglas-fir
- Leaving modest numbers of healthy, medium-sized and smaller ponderosa pines

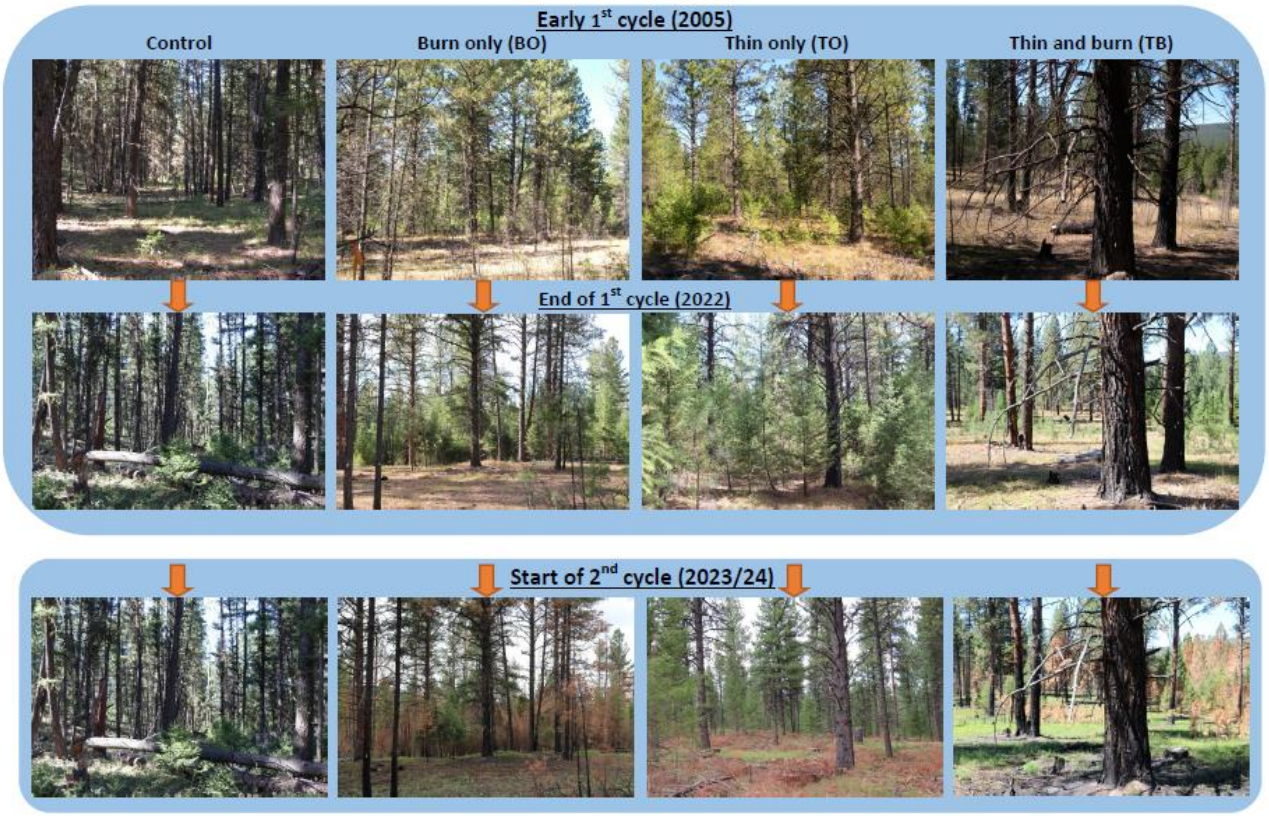

Figure 4. Photopoints showing how the treatments have changed from 3 years after the first thinning and prescribed burns through 2024.

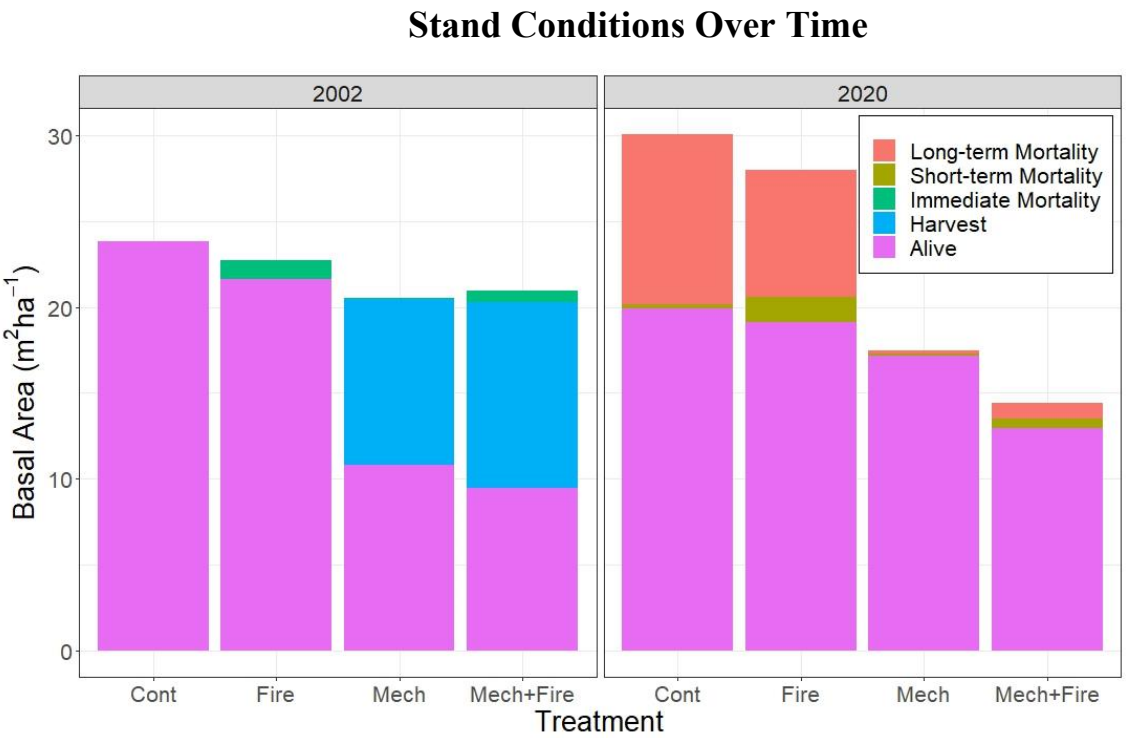

Figure 5. Overstory basal area (trees ≥ 10.16 cm dbh) immediately post-treatment (2002) and 18 years later (2020). Immediate mortality includes trees that died between the pretreatment and 1-year post-treatment measurements. Short-term mortality includes trees dying 2-4 years post-treatment. Long-term mortality includes trees dying 5-18 years post-treatment (mostly from mountain pine beetle.

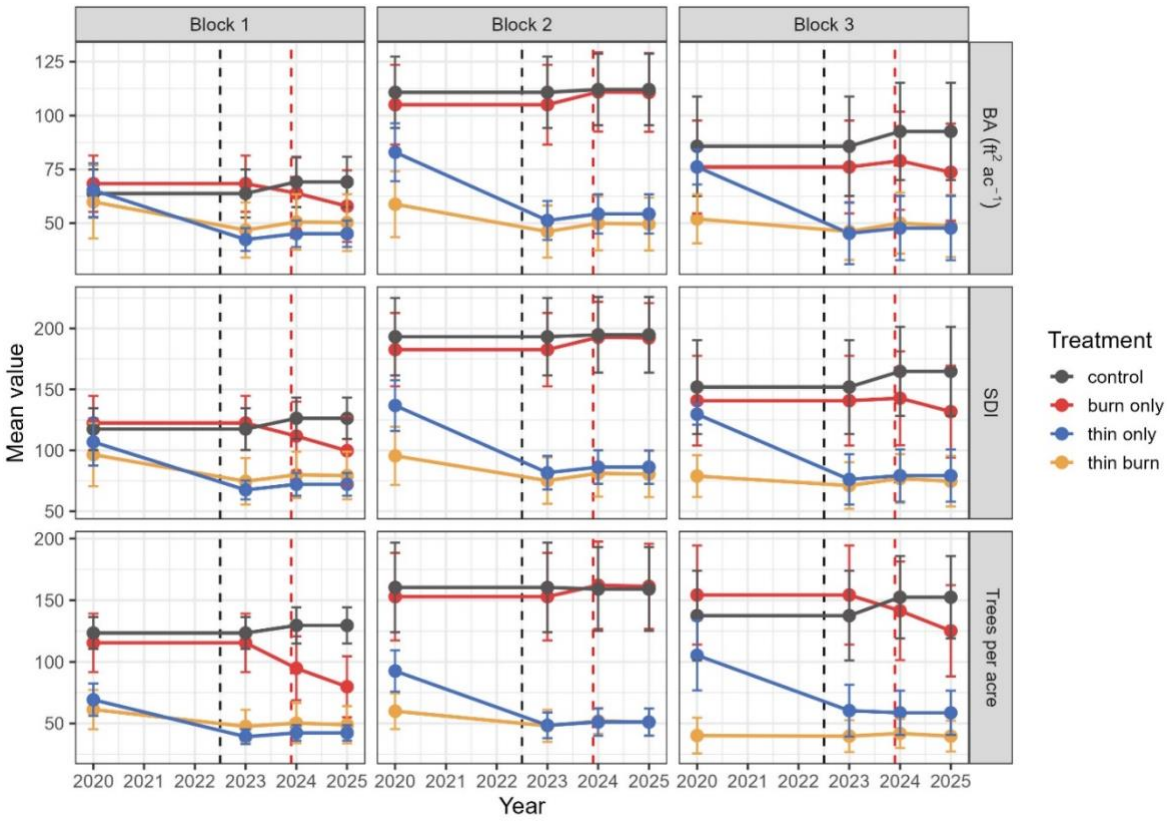

Figure 6. Basal area, stand density index, and tree density before 2nd entry, post-harvest (2023), and post-burn (2024).

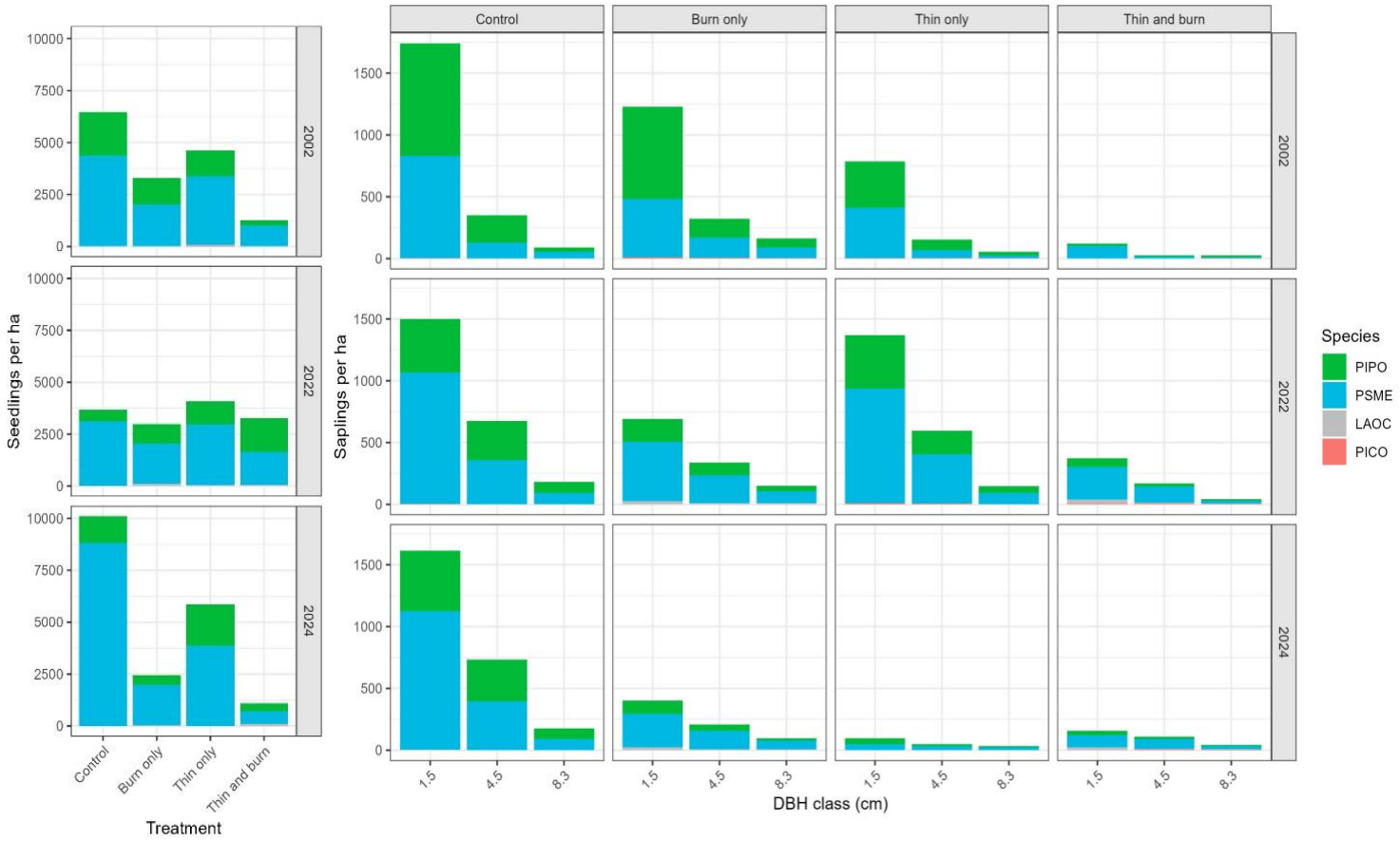

Figure. 7 Seedlings (<1.37 m tall) and saplings (>1.37 m and <10 cm DBH) density by treatment.

Understory Responses

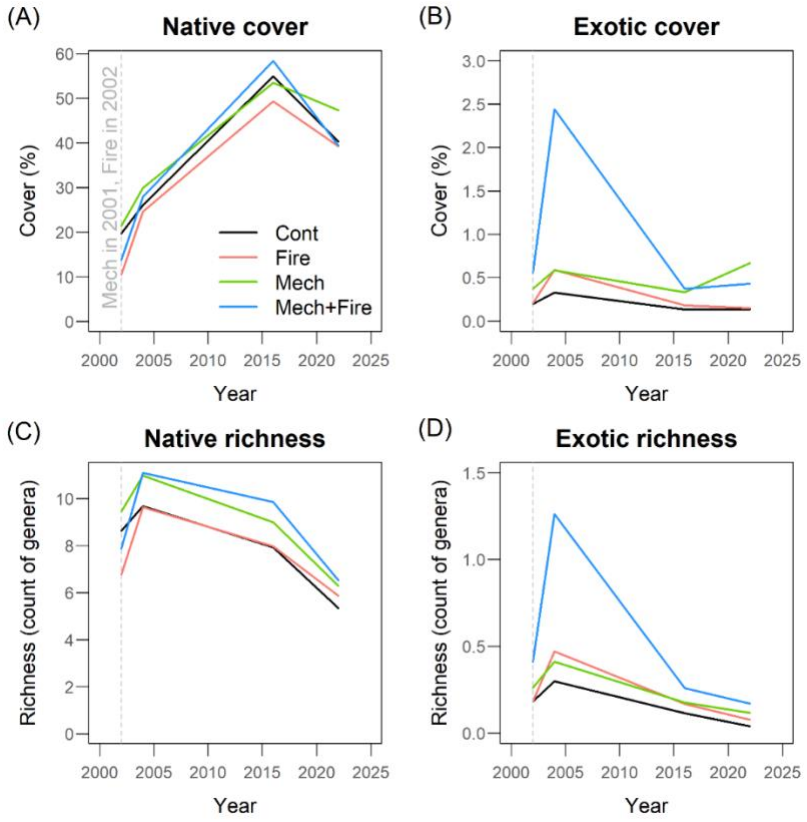

Figure 8. Average native and exotic (A, B) understory percentage cover and (C, D) richness (count of genera) on 1 m2 quadrats over time by treatment. Measurement years were 2002, 2004, 2016, and 2022; only 2002 and 2022 were used for testing.

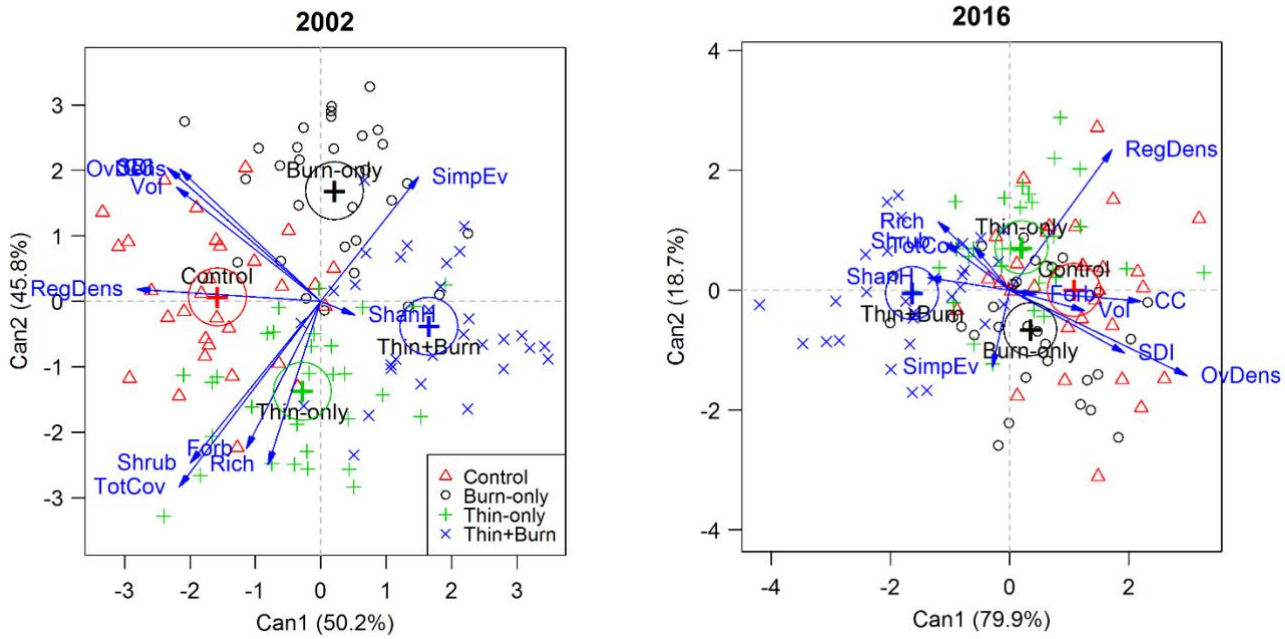

Figure 9. Canonical discriminant analysis of plot-scale multivariate communities in 2002 (left) and 2016 (right). First two canonical axes are shown for each year ($P < 0.05$ except Can2 in 2016), labeled with percent variance explained by axis. Treatment mean centroids are symbolized by circle and crosshairs. Labeled arrows show direction and relative magnitude of variable loading in canonical space.

Fuel Treatment Effectiveness During A Mountain Pine Beetle Outbreak

A mountain pine beetle (MPB) outbreak occurred ~5 years after treatment implementation (2005-2012). Ponderosa pine mortality from MPB was highest in the control (50%) and burn- only (39%) treatments, compared to almost no mortality in the thin-only and thin-burn treatments. After the outbreak, ponderosa pine remained dominant in the thin and thin-burn treatments, but the control and burn-only shifted in species dominance to Douglas-fir. Treatments designed to increase resistance to high-severity fire in ponderosa pine-dominated forests in the Northern Rockies can also increase resistance to MPB, even during an outbreak.

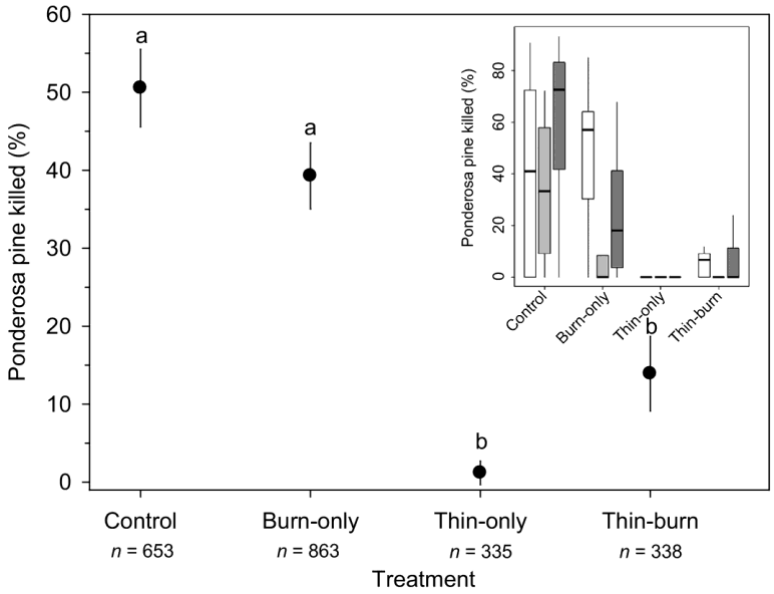

Figure 10. Mean (SE) of percent of ponderosa pine killed by mountain pine beetle between 2005 and 2012. Different letters indicate mortality is significantly different between treatments (α = 0.05). Study total number of host trees noted below treatment. The inset shows the percentage of ponderosa pine killed by mountain pine beetle between 2005 and 2012 by experimental block.

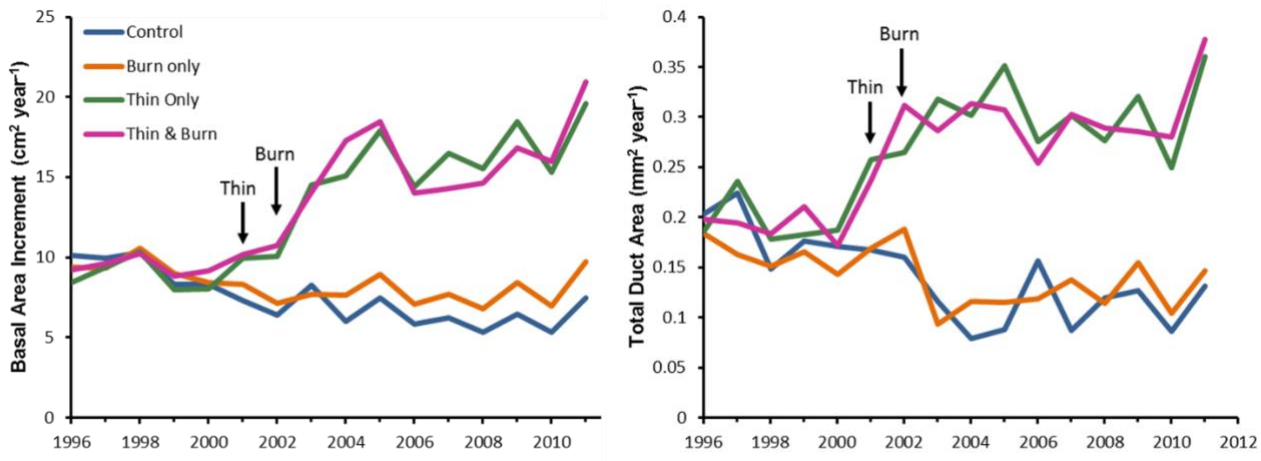

Figure 11. Left: Yearly mean basal area increment and right: total duct area by treatment. Error bars are standard error. Arrows denote year of first thinning (winter 2000/2001) and prescribed burn (Spring 2002).

Fuel Changes

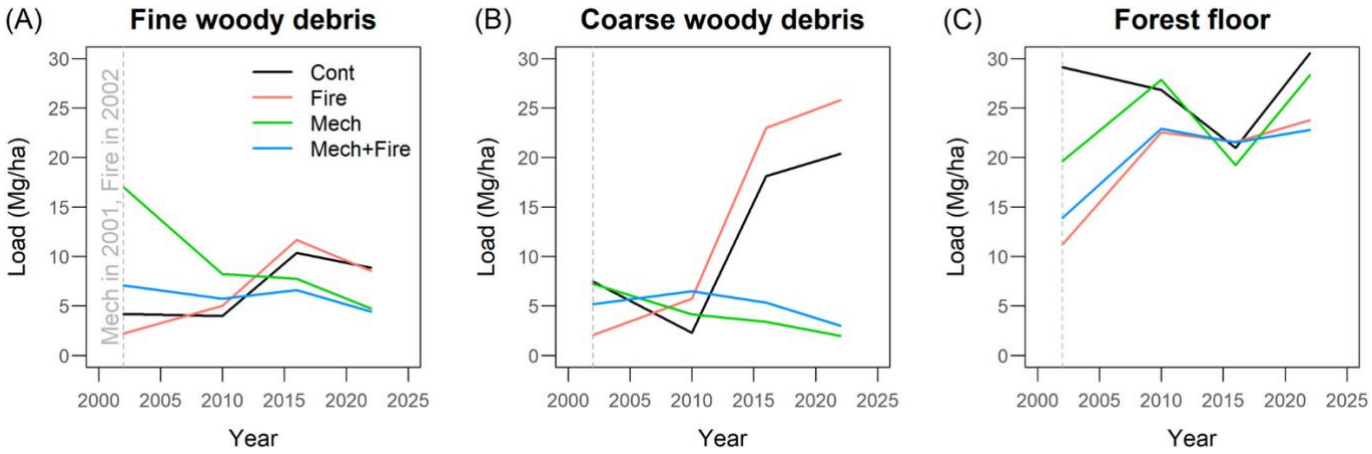

Figure 12. (A) Fine woody debris, (B) coarse woody debris, and (C) forest floor surface fuel loads over time by treatment. Measurement years were 2002, 2010, 2016, and 2022; only 2002 and 2022 were used for testing. The study area was affected by a regional mountain pine beetle outbreak between 2005 and 2012, especially in the Cont and Fire treatment.

Fire-caused Tree Mortality from 2nd Entry Burn

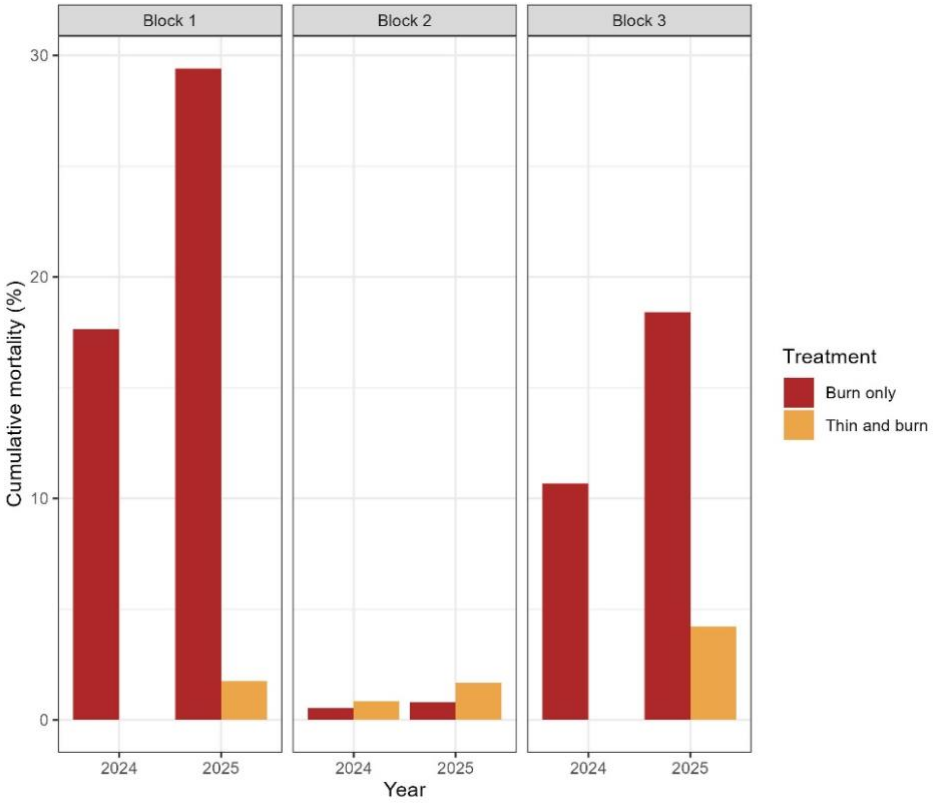

Figure 13. Cumulative tree mortality (>10 cm DBH) after the spring 2024 re-entry prescribed burns.

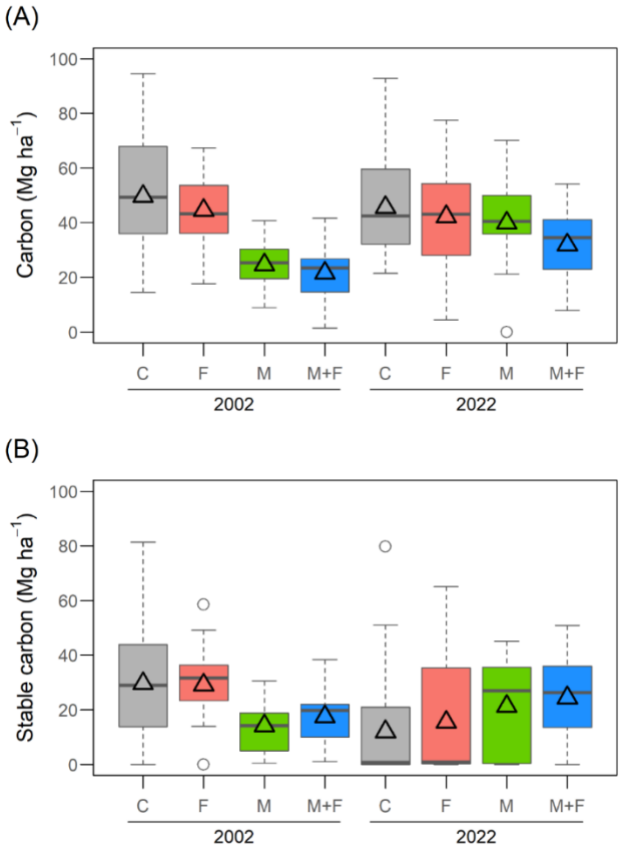

Figure 14. (A) Probability of torching and (B) overstory mortality (by basal area) boxplots by treatment from modeled fire in 2002, immediately following treatment, and 2022, 20-years post-treatment. Fire was modeled with the Fire and Fuels Extension of the Forest Vegetation Simulator under "severe" fire weather conditions. Treatment levels: C=Cont, F=Fire, M=Mech, M+F=Mech+Fire. Boxplots illustrate median, first and third quartiles, and range of plot-scale data; triangles are plotted at treatment-scale means.

Figure 15. (A) Total aboveground live carbon and (B) stable aboveground live carbon boxplots by treatment in 2002, immediately following treatment, and 2022, 20-years post-treatment. Stable aboveground live carbon was calculated as that remaining after modeled fire. Fire was modeled with the Fire and Fuels Extension of the Forest Vegetation Simulator under "severe" fire weather conditions. Treatment levels: C=Cont, F=Fire, M=Mech, M+F=Mech+Fire. Boxplots illustrate median, first and third quartiles, and range of plot-scale data; triangles are plotted at treatment-scale means.